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(54) Drill.

(57) The invention relates to a drill comprising a shaft with chip-conveying flutes and a drill head with two or more cutting elements. Each of these comprises a cutting edge (7) which is delimited between a chip-breaking surface and a relief surface (9) and which, at least in the proximity of the geometrical center or rotation axis of the drill, comprises a curved portion (12). The cutting edge (7) of the individual cutting element is located with its curved portion (12) in such a way that a tangential point (24) on a straight line (E) that extends from the center axis and tangentially touches said curved edge portion, is provided distantly from the center axis of the drill. In the immediate proximity of this center axis, the cutting edge is terminated in a small material portion (23) which is common for all cutting edges and which extends between the cutting elements in order to serve as a center punch for centering the drill.

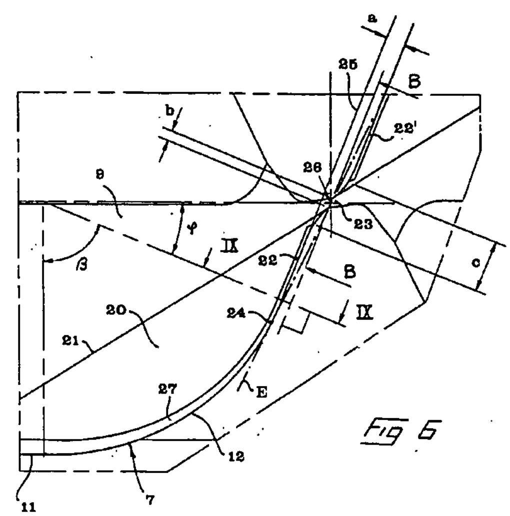

Fig 6

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The present invention relates to a drill comprising a shaft with chip-conveying flutes and a drill head at the front of the shaft, with two or more cutting elements, each of which comprising at least one cutting edge which is delimited between a chip breaking surface and a relief surface and which at least in the vicinity of the the geometric center or rotation axis of the drill comprises a curved section.

A drill of this type is previously known from SE-B-440 324 (& SE-A-7812393-2). This known drill has good cutting ability and enables drilling with fast feed. However, in practice it is marred by the disadvantage of an inferior centering ability. In relation with a reference plane that cuts the central rotation axis of the drill in an acute angle of 60 to 70° to a main plane that is parallel with the straight main sections of the cutting edges (or about centrally in the sectors being defined by the ends of the chip-conveying flutes), the curved section of each cutting edge protrudes a bit past this reference plane, at the same time as the relief surface of each cutting element, which relief surface is situated behind the cutting edge in the direction of rotation, extends as an uninterrupted surface up to the curved section of the cutting edge. Moreover, the curved section starts its curve already in the immediate proximity of the centrum axis of the drill. This geometry brings about that the two cutting edges form a chisel-like configuration with a pronounced longitudinal extension in the area where they converge. When this chisel configuration is put against a work piece for drilling and entering into the same, it tends to slide transversally upon the surface of the workpiece. In practice, the entering surface of the workpiece is rarely perfectly plane and rarely oriented absolutely perpendicularly to the rotation axis of the drill. On the contrary, the entering surface is often rough or uneven and can be inclined locally or entirely one or a few degrees in relation to the drill axis. Also at a very forcible placing of the drill against the workpiece, the chisel configuration of the drill tends to move at least a little transversally, without any capacity of finding a distinct centration. This tendency is particularly pronounced just at the entering of the workpiece, but the generally bad centering ability is also present when the drill head has worked its way into the workpiece, causing vibrations in the workpiece and in the drill itself. These inconveniences also become noticeable when working with relatively long drills (drills whose length is equal to or exceeds 3,5 times the diameter of the drill), particularly in connection with crank fixations of the workpiece. When vibrations arise, these influence negatively the quality of the drilled hole and the durability of the drill.

One object of the present invention is to eliminate the above mentioned inconveniences of previously known drills and create a drill with good centering ability. Thus, a primary object of the present invention is to confer to the head of the drill such a geometry that it becomes self-centering already at the placing against and the initial penetration of a workpiece and maintains a good centering ability also during the continuing penetration of the workpiece, whereby the good centering ability shall be possible to achieve without the necessity of large feeding or placing forces. Another object is to attain a good centering ability without the necessity of substantially reducing the active cutting edge length.

According to the present invention, at least the primary object is brought about by the characteristics in the characterizing part of claim 1. Preferred embodiments of the present invention are defined in claims 2 to 8.

Here follows a short presentation of the drawings:

Figure 1 shows a perspective view of the front or free end of a drill according to the present invention.

Figure 2 shows a similar perspective view which has been turned about 90° in relation to the view of Figure 1.

Figure 3 shows a side view of the head of the drill.

Figure 4 shows a partially cut end view of the drill head according to Figure 3.

Figure 5 shows a second side view of the same drill head, which has been turned 90° in relation to the view according to Figure 3.

Figure 6 shows an extreme amplification of a central section of the tip of the drill head, seen as an end view in the same way as in Figure 4.

Figure 7 shows an extreme amplification of the central tip section of the drill head, seen in the same way as in Figure 3.

Figure 8 shows a partial cross-section along line VIII-VIII in Figure 3.

Figure 9 shows the cross-section IX-IX in Figure 6.

Figure 10 shows a schematic view as seen in a reference plane B-B in Figure 6.

The drill shown in figures 1 and 2 comprises a shaft 1 and a drill head designated in its entirety by 2. Two helical or screw-formed flutes 3,3' are formed in the shaft 1, which flutes are delimited by analogous, helically formed protruding lands 4,4'. The drill head 2 comprises two, in the present case identical, but inverted cutting elements 5,5' which extend in each other's extension in a common main plane A-A that cuts the centrum or rotation axis of the drill (in figure 3 this axis is designated by a C). In figure 2 a reference plane B-B also extends through the centrum axis of the drill, however in an acute angle in relation to the main plane A-A, more specifically in an angle of about 68°. In this embodiment, the cutting elements 5,5' are made as parts of a common cutting body, e.g. of cemented carbide, which has been fixated upon the shaft by a soldered joint 6 and thereafter ground to its final shape, as shown in the drawings. Although this embodiment is preferred in prac-

tice, it is within the scope of the present invention to form the two cutting elements 5,5' of the drill head as an integral part of the drill shaft 1 as such, i.e., as ground parts of the same.

Each individual cutting element 5,5' comprises a cutting edge designated in its entirety by 7, which is generally delimited between on the one hand a chip-breaking surface 8 and on the other hand, a relief surface 9. In relation with the total width of the cutting element, the relief surface 9 has a reduced width by the fact that the piece of which the cutting head has been produced, has a countersunk surface 10 in the area behind the relief surface, seen in the direction of rotation of the drill. By the reduction of the width of the surface 9 to about half of the total width of the cutting head, the necessary grinding of the relief surface is simplified and speeded up. The individual cutting edge 7 comprises a main section 11 which in the present case is substantially straight and which extends from the periphery of the drillhead and which continues into a curved section 12 closer to the centrum axis of the drill. The chip surface 8 is also formed with a restricted width in order to simplify grinding of the same. Of this reason, a recess is formed already in the blank of the drill head, in the area below the peripheral part of the chip surface, this recess being delimited on the one hand by an inclined plane surface 13 and on the other hand by a vaulted surface 14. At its peripheral end the cutting edge 7 continues into an edge section 15 that is substantially axial, behind which section there is a flange surface 16 which has been conferred a restricted width by the fact that the end surface of the drill head has been formed with at least one countersunk surface 17 in the area behind a delimiting line 18. By the existence of this axial edge section, it is possible to grind the cutting elements without changing the effective diameter of the drill head. In connection with figures 1 and 2 it should eventually be noted that each individual chip-conveying flute 3 ends in a restricted space (19 in figure 1) in the area between the cutting elements 5,5'. More specifically, this restricted space 19 is situated between on the one hand the curved cutting edge section 12 of the one cutting element, and on the other hand the inner end of the countersunk relief surface 10 of the other cutting element. This is true for both sides of the central main plane A-A.

After figures 1 and 2 having given a general picture of the configuration of the drill according to the present invention, reference is now made to figures 3 to 10, which give a more detailed explanation of the geometric form of the drill.

In figure 3 D-D is an imaginary plane extending through the tip of the drill, perpendicularly to the centrum axis C. The angle α between this transversal plane D-D and the straight cutting edge 11 according to the shown embodiment amounts to around 20°, which means that the tip main angle of the drill amounts to about 140°. This is a conventional tip angle which can very upwards and downwards. In this connection it should also be mentioned that the flange surface 16 is somewhat inclined in relation to the centrum axis C, more specifically in such a way that the rear section of the surface is situated somewhat nearer to the axis C than the fore section (not visible on the drawings), thus conferring a certain clearance to the surface. In practice this clearance or relief angle (not shown) can be extremely small.

In figure 4 it is shown that the primary relief surface 9 of each cutting element 5,5' comprises a secondary, ground relief surface 20 in the area of the curved cutting edge section 12, which surface is delimited by a break or delimiting line 21 which in the present case is substantially straight.

In figure 6 the gist of the present invention is illustrated. This figure shows the tip portion of the drill head amplified 8X in comparison with figure 4 and illustrates how the curved section 12 of the cutting edge 7 extends along the curved line of a circle sector from the straight main section 11, said circle sector having the circle angle β which in the shown embodiment is about 68° (the complementary angle ψ is thus about 22°). Further according to the illustrated embodiment, the curved cutting edge section 12 continues into a second, straight cutting edge section 22 in the proximity of the drill centrum. The reference plane B-B which was mentioned in connection with figure 2, extends according to the shown example obliquely towards the main plane A-A, more specifically in an angle that corresponds with the sector angle β, i.e., about 68°. In a way that is characteristic for the present invention, the cutting edges 7,7' of the two cutting elements are so formed near to the center of the drill, that the inner, straight cutting edge sections 22,22' are distanced outwardly from the reference plane B (or backwardly from said plane when seen in the direction of rotation of the drill), whereby the cutting edges in the immediate proximity of the centrum of the drill are terminated in a common, diminutive material part 23 that extends between the two cutting elements 5,5' in order to serve as a drill-centering center punch. Hence, each curved cutting edge section 12 is so located that a tangential point 24 on an imaginary straight line E (shown as a dashed-dotted line in figure 6), which cuts the centrum C of the drill and is commonly touched by the curved cutting edge sections 22,22' of the two cutting elements, is distanced from the centrum C of the drill. It can be seen in figure 6 that the straight cutting edge section 22 next to the drill's center axis extends substantially parallelly to the reference plane B-B, whereby an imaginary extension line 25 to the cutting edge section 22 on the cutting element 5 extends parallelly to the analogous straight cutting edge section 22' on the other cutting element 5' and is located on a certain distance _a_ from the latter. In the shown embodiment,

the distance a amounts to about 0,3 mm, although smaller and larger values are also feasible. However, in practice the distance a should be between 0,05 and 0,50 mm. The central punching section 23 comprises a break line 26 in the absolut center of the drill, which line is formed at the grinding of the relief surfaces 9 of the respective cutting element. The measure b of the break or edge line 26 should be smaller than the gap a and amounts to about 0,1 mm. Although this width measure of the center punch section may ary, it should be within the range of 0,05 to 0,25 mm. The measure c, which marks the distance between the points at which the straight cutting edge sections 22,22' transpose into the center punch section 23, can be 5 to 10X larger than measure b. It should also be mentioned that the measure a preferrably is 2 to 4 times larger than measure b. Although material section 23 thus has relatively small dimensions, it nevertheless forms a distinct center punch that hits the surface of the workpiece first and gets a hold in it. In practice, the relief angle ε of the surface 9 (see figure 8) amounts to about 8°. Therefore, if the surface 9 were to be formed as an uninterrupted plane surface from its peripheral end to the curved cutting edge section 12 at the opposite, inner end, the curved cutting edge section could be located on the same level as the center punch 23, seen in the feeding direction of the drill, particularly so the outer part of the curved cutting edge section, i.e., the section that is distanced from the main plane A-A. In order to avoid this, the previously mentioned, secondary relief surface 20 is ground into the surface 9 adjacent to the curved cutting edge section 12. As can be further distinguished from the cross-section in figure 9, which is amplified in comparison with figure 8, the secondary relief surface 20 forms an angle λ with the primary relief surface 9 that can amount to about 13a, although smaller and larger angles are also feasible. By grinding the surface 20, the drill head will also have an acute angle in a direction transversal to the main plane A-A. More specifically, each of the two straight, inner cutting edge sections 22,22' will form a certain angle ω with the transversal plane D-D, as can be seen in figure 10. In practice, the angle ω can amount to about 5°, which means that the secondary tip angle in the plane B-B will amount to about 170°. Of course, the angle ω can be smaller or larger than 5°. However, the thus formed secondary tip angle should be between 160 and 179°, suitably between 165 and 175°.

The cutting edge 7 on each cutting element does not have the form of a completely sharply ground edge line between the chip surface 8 and the relief surface 9. On the contrary, the cutting edge comprises a reinforcing face 27 (see figures 6, 8 and 9) consisting of a special ground surface with an extremely small width in the area between the chip surface and the relief surface. In practice, the width d (see figure 8) of this reinforcing face can lie within the range of 0,01 to 0,30 mm, preferrably around 0,10 mm. The width of the reinforcing face can vary along the cutting edge. Due to the existence of this reinforcing face, the cutting edge gets a considerably larger strength and longer durability than a sharp-ground cutting edge which is more apt to damages.

In accordance with a preferred embodiment of the present invention, the cutting edge is formed with a varying chip angle along its extension from its peripheral section to its inner end adjacent to the center punch section 23. More specifically, the cutting edge has a negative chip angle in the area of its inner straight section 22 and along the innermost part of its curved section 12. As can be seen from the cross-section IX-IX in figure 9, which is cut around the area between the straight section 22 and the curved section 12, the cutting edge in this area has a negative chip angle τ of about 5°. However, in the cross-section VIII-VIII, which is taken at a larger distance from the center axis of the drill along the curved cutting edge section, the chip angle τ' is positive. However, this positive chip angle τ' should amount to maximally about 10°. Such a chip angle of about 10° can advantageously be formed along the whole extension of the straight main section 11 of the cutting edge. Hence, the chip angle is gradually changed from being negative in the area next to the center of the drill, to transposing into an increasingly more positive chip angle, as from a not further defined turn point somewhere along the curved cutting edge section 12.

Since the chip angle thus is negative adjacent to the center of the drill, the cutting edge is extraordinarily strong in the area where it is submitted to the largest strain.

When the described drill is brought into contact with a workpiece, the center punch 23, which is formed as a distinct tip, will first enter into the workpiece, whereafter the two cutting edges, starting with the two inner cutting edge sections 22,22', which are straight and behind the reference plane B-B in the direction of rotation, gradually become active radially outwards from the center axis, upto the point when all the cutting edges are fully activated by the workpiece. This gradual activation is considerably simplified by the fact that the drill tip has a tip angle not only in the main plane A-A, but also a certain secondary tip angle in the reference plane B-B, as shown in figure 10. In this way, the central pressing zone of the drill is minimized when entering the workpiece, thus reducing the necessary feeding or pressing force. Tests have indicated that the feeding force can be considerably reduced in comparison with the force that has been previously considered necessary. Moreover, the center punch section 23 in combination with the geometry in general guarantees that the drill is centered in a reliable way, not only at the entering of the workpiece but also at the continued drilling in the same. Also at relatively cranky fixations of the workpiece,

the drill becomes auto-centering, hence minimizing any tendency of vibrations. This improves the quality of the drilled hole and increases the durability of the drill quite considerably.

Obviously, the invention is not restricted to the embodiment described above. Thus, it is not absolutely necessary to make section 22 of the cutting edge, which section extends from the tangential point 24 to the central center punch section 23, as an absolutely straight cutting edge section. Within the scope of the invention, this section can also be more or less arch-formed. The only essential point is that the cutting edge section in question be located in the area behind the reference plane B-B. Further, although the described embodiment comprises a drill head in the form of a cemented carbide body that is fixedly joined with the shaft by a soldered joint, the invention also foresees detachable cutting bodies, for instance by being provided with a central tap which can be introduced into a central seat at the end of the shaft and can be fixed thereto by one or several screws which can be tightened from the side of the shaft. Further it should be noted that the cutting element can be formed with a broken or divided cutting edge, although the embodiment shown in the drawings comprises a continuous cutting edge on each cutting element 5,5'. Thus, the individual cutting element can have its main part 11 or parts of it countersunk in relation with the cutting edge in general, i.e. retracted a bit rearwardly in axial direction from a cutting edge section including the curved section 12. Further, it is underlined that the invention is not restricted to drills comprising precisely two cutting elements with pertaining cutting elements. Thus, the invention can also be applied on drills with several cutting elements, i.e. with three or four cutting elements.

Claims

1. A drill comprising a shaft (1) with chip-conveying flutes (3, 3') and a drill head (2) with two or more cutting elements (5, 5'), each of which being provided with at least one cutting edge (7) which is delimited between a chip-breaking surface (8) and a relief surface (9) and which at least in the proximity of the geometrical center or rotation axis (C) of the drill comprises a curved section (12),
   characterized that the cutting edge (7) of the individual cutting element (5, 5') is located with its curved cutting edge section (12) in such a way that the tangential point (24) on a straight line (E), that extends from said drill center axis (C) while tangentially touching said curved section (12), is provided distantly from the center axis (C), and the cutting edge located next to and adjacent said center axis is terminated be a small material portion (23) that is common for all cutting edges and that extends between the cutting elements (5, 5') in order to serve as a center punch for centering the drill.

2. Drill according to claim 1 comprising two cutting elements (5, 5'), characterized in that the curved section (12) of the cutting edge (7) continues into a substantially straight portion (22) as from a point adjacent its tangential point (24) on said tangential line (E), which straight portion extends to the center punch portion (23), whereby an imaginary, straight extension line (25) of the straight portion (22) of the cutting edge (7) of the one cutting element (5) is substantially parallel with a corresponding straight portion (22') of the cutting edge of the other cutting element (5') and is separate from the latter.

3. Drill according to claim 2, characterized in that the distance (a) between the straight portion (22') of the one cutting edge and the imaginary extension line (25) of the corresponding straight portion of the other cutting edge, is larger, e.g. 2 to 4 times larger, than the width (b) of the center punch section (23).

4. Drill according to any of the previous claims, characterized in that the width of the center punch section (23) is 0,05 to 0,25 mm, suitably about 0,10 mm.

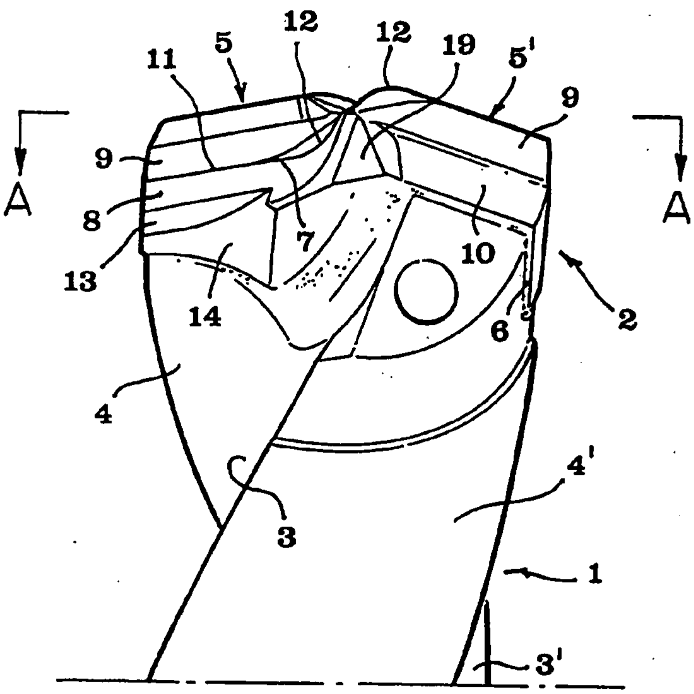
5. Drill according to any of the previous claims, characterized in that a secondary relief surface (20) is ground into the primary relief surface (9) of the cutting element (5, 5'), adjacent to the curved section (12) of the cutting element (7), said secondary relief surface (20) ensuring a secondary acute angle in a reference plane (B) in immediate proximity of said tangential line (E).

6. Drill according to claim 5, characterized in that said secondary acute angle lies within the range of 160 to 179°, suitably 165 to 175°.

7. Drill according to claim 5 or 6, characterized in that the secondary relief surface (20) is delimited by a break line (21) which extends from a point situated somewhere between the center punch section (23) and said tangential point (24), preferrably in the center punch section as such, to a point along the preferrably straight main portion (11) of the cutting edge (7).

8. Drill according to anyone of the previous claims, characterized in that the angle (τ) of the chip face is negative in the area of the curved cutting edge portion (12) that is located adjacent the center

axis of the drill, and gradually changes to a positive angle (τ') closer to the periphery of the drill.


12
12
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19
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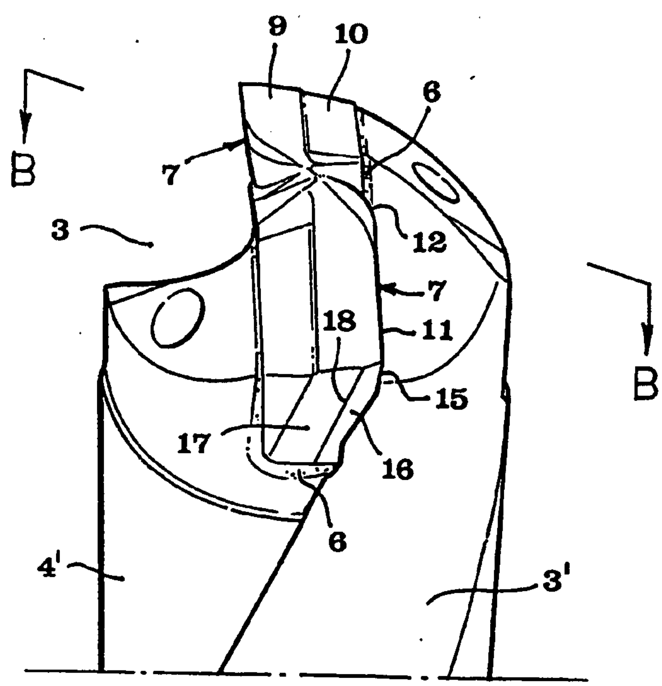
Fig 1


9
10
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4'
3'

Fig 2

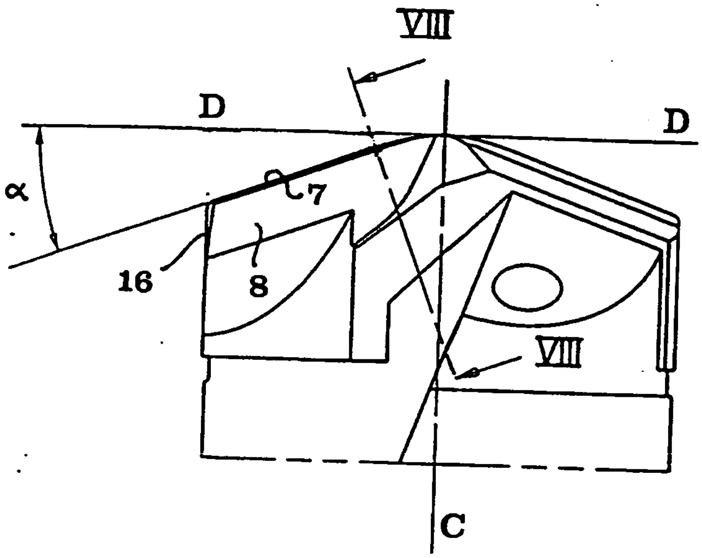


Fig 3

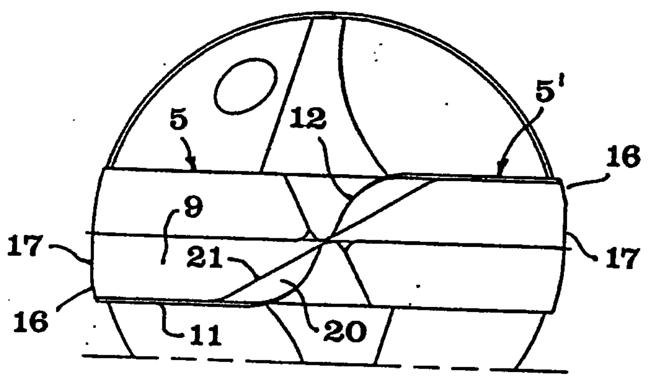
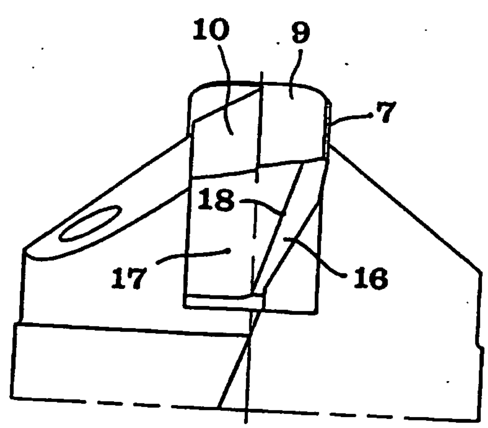


Fig 4

Fig 5



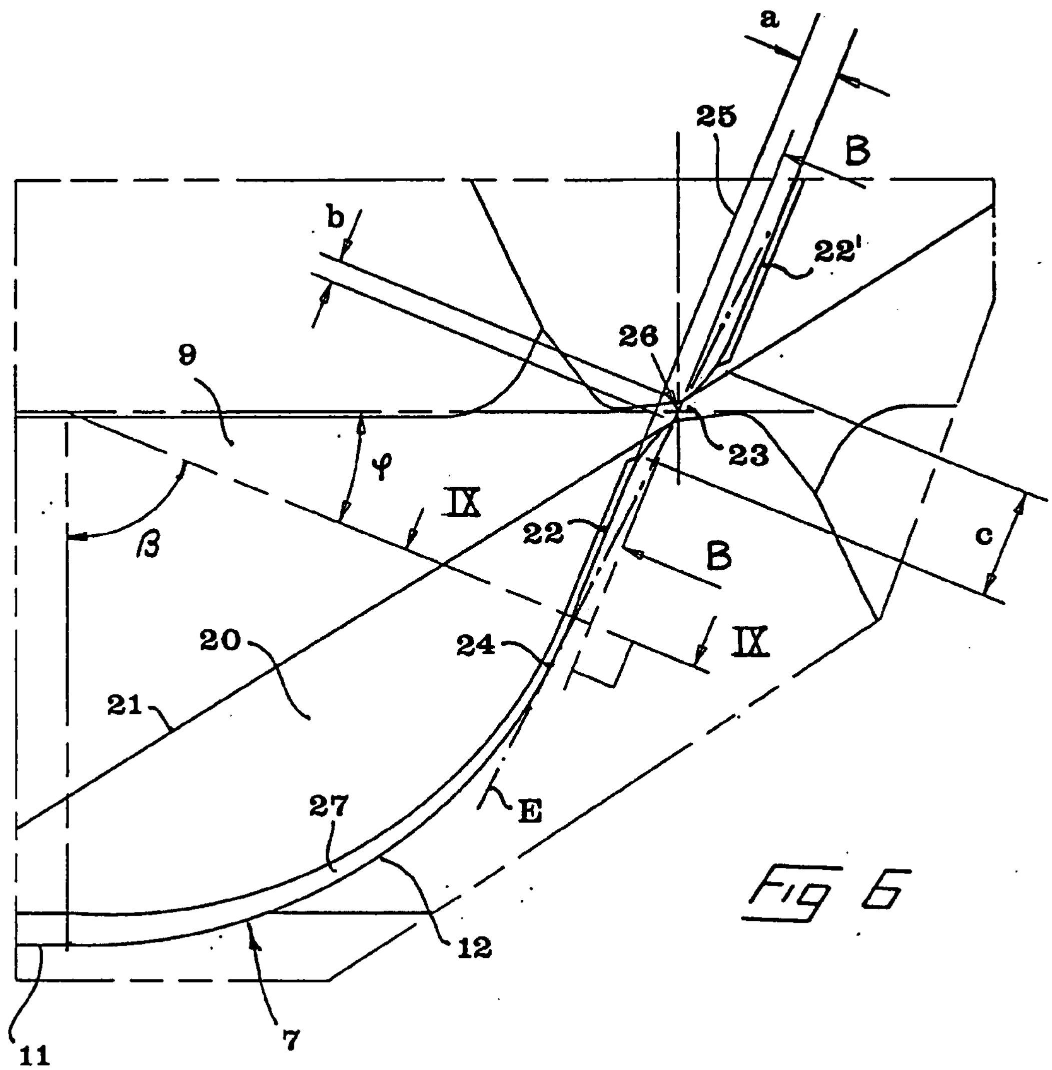


Fig 6

Fig 7

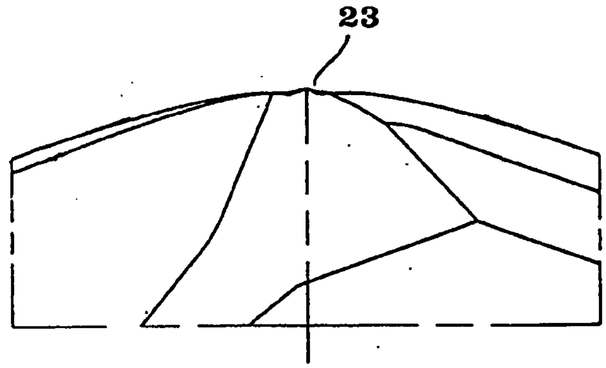


Fig 8

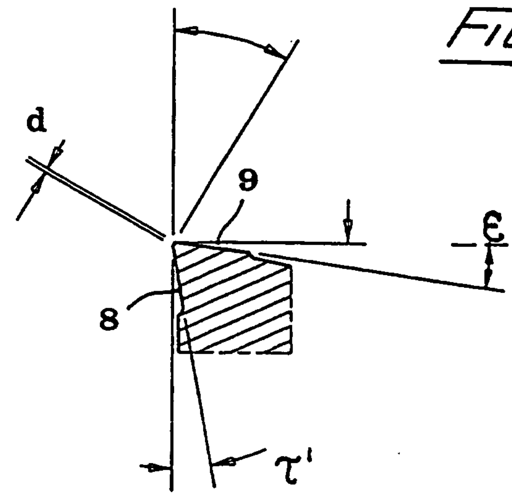
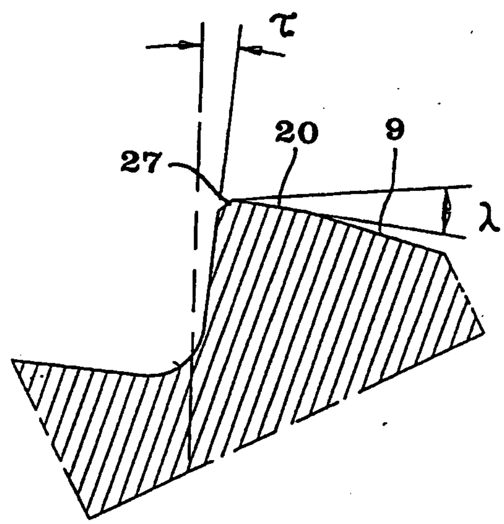


Fig 9



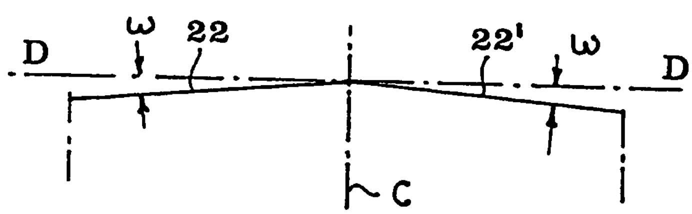


Fig 10

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EUROPEAN SEARCH REPORT

Application Number

EP 93 85 0171

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	DE-A-2 851 183 (R. HOSOI) * claims 1-5; figures 1-14 *	1-3	B23B51/02
Y	FR-A-1 190 274 (A. JANIN) * page 1, left column - page 2, right column; figures 1-5 *	1-3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B23B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	30 DECEMBER 1993	WUNDERLICH J.

CATEGORY OF CITED DOCUMENTS

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